JET PROPULSION LABORATORY INTEROFFICE MEMORANDUM

September 1, 2004

TO: E. Burke

FROM: S. Guduru

SUBJECT: Determine the impact of not using S-band Uplink from Madrid for Voyager 1, Voyager2 and Ulysses.

**Purpose**

The purpose of this study is to determine the impact of not using Deep Space S-band uplink capability at SPC-60 (Madrid, Spain) of the DSN. Mars Express, Rosetta, Ulysses, Voyager1 and Voyager2 are the missions that use this functionality. Both Mars Express and Rosetta have X-band as their prime and have agreed not to use S-band at Madrid. Thus the study only focuses on Voyager1, Voyager2 and Ulysses missions. The S-band uplink communication at SPC-60 interferes with Spain's IMT2000 cell phone frequencies. To eliminate this interference DSN is analyzing the impact of not using Deep Space S-band uplink in Spain beginning in 2005.

**Summary**

The impact on Voyager1 (VGR1) is not significant. VGR1's current requirement of one 2.5-hour uplink pass per week is minimal and can be moved from Madrid (MAD) to Goldstone (GDS). When DSS-14 has planned downtime they will have to use DSS-43.

Voyager 2 (VGR 2) only has Canberra (CAN) view and requests all support at DSS-43, 34. Hence not using S-band uplink at Madrid does not impact VGR2 directly.

Ulysses (ULYS) has a significant impact as a result of not having S-band uplink at Madrid. Its viewperiod does not fall within the IMT2000 low traffic period. Hence it has to use either the CAN or the GDS view period for the uplink pass to avoid interference. Moving the supports from DSS-54 to DSS-24, 34 and/or DSS-14, 43 creates a significant contention at these stations especially at DSS-34 when DSS-43 is down. During this period of high activity, especially in weeks 29 through 52 of 2005 when DSS-43 is down, ULYS has to reduce uplink time at DSS-34 and use downlink at Madrid. ULYS can also use DSS-14, 43 instead of DSS-24, 34 during week 26 of 2005 and in weeks 4 through 10 of 2006 to increase its supportability. To reduce the contention caused by limiting ULYS to use GDS and CAN for S-band uplink, it must limit the use of S-band uplink per day and combine the supports with another X-band downlink only antenna at 34HEF or 34 BWG2.

**Assumptions**

The end of extended mission date is 09/30/06 for VGR1, VGR2 and ULYS. Requirements beyond this date are not considered in this study.

DSS-24 is down in week 26 of 2005 and in weeks 36 through 42 of 2006.

DSS-34 is down in weeks 7 through 14 of 2005.

DSS-43 is down from week 29 through end of year 2005 for antenna controller replacement and hydrostatic bearing maintenance.

**Methodology:**

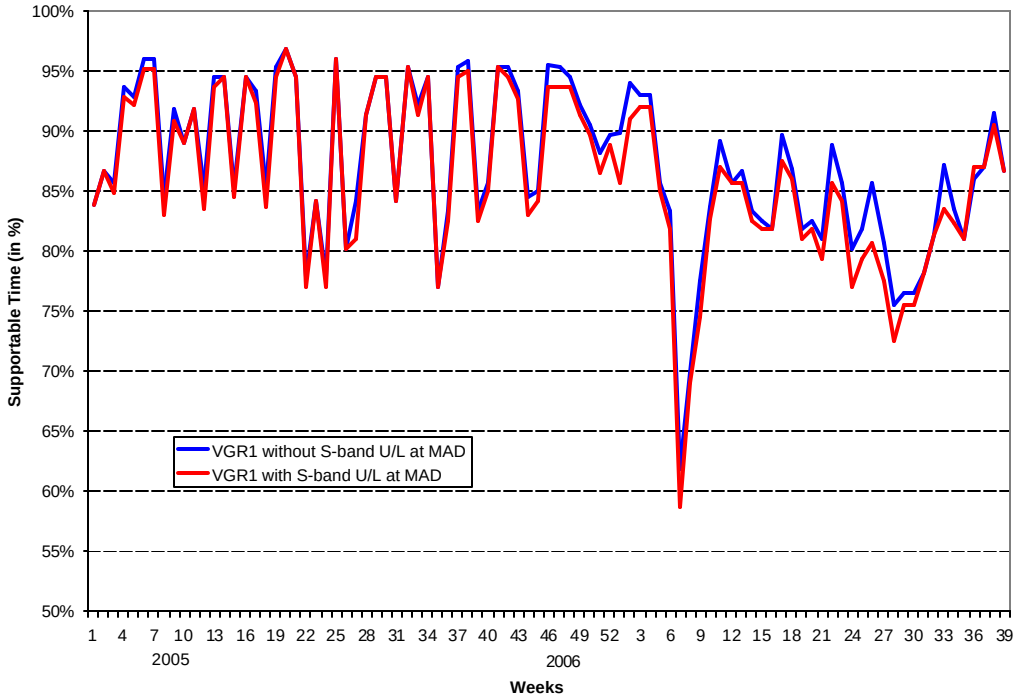
This study focuses on the period from 01/01/05 till 09/30/06.

Analysis was accomplished using the FASTER (Forecasting and Scheduling Tool for Earth-based Resources) forecasting system and the updated mission set database for the August 2004 Resource Allocation Review Board (RARB).

The impact on each of these above missions is discussed in detail below.

**Voyager 1**

Figure 1 **VGR1 Supportablity with/without S-band Uplink at Madrid in 2005-2006**




VGR 1 requests one 2.5-hour support weekly either at DSS-14 (GDS) or DSS-63 (MAD) for routine uplink. Figure 1 shows a comparison of the weekly forecasted supportable percentage of time when VGR1 has the routine uplink support at both GDS and MAD to when all routine uplink is scheduled at GDS.

In 2005 there is practically no difference. However in 2006 there is a slight increase (2-6%) in supportable percentage when all uplink support is scheduled at DSS-14 only. The weekly requested uplink time is low hence moving all uplink support to DSS-14 does not

impact VGR1 and the DSN significantly. An exception to this recommendation may occur when DSS-14 has a planned downtime for more than 7 days consecutively.

**Voyager 2**

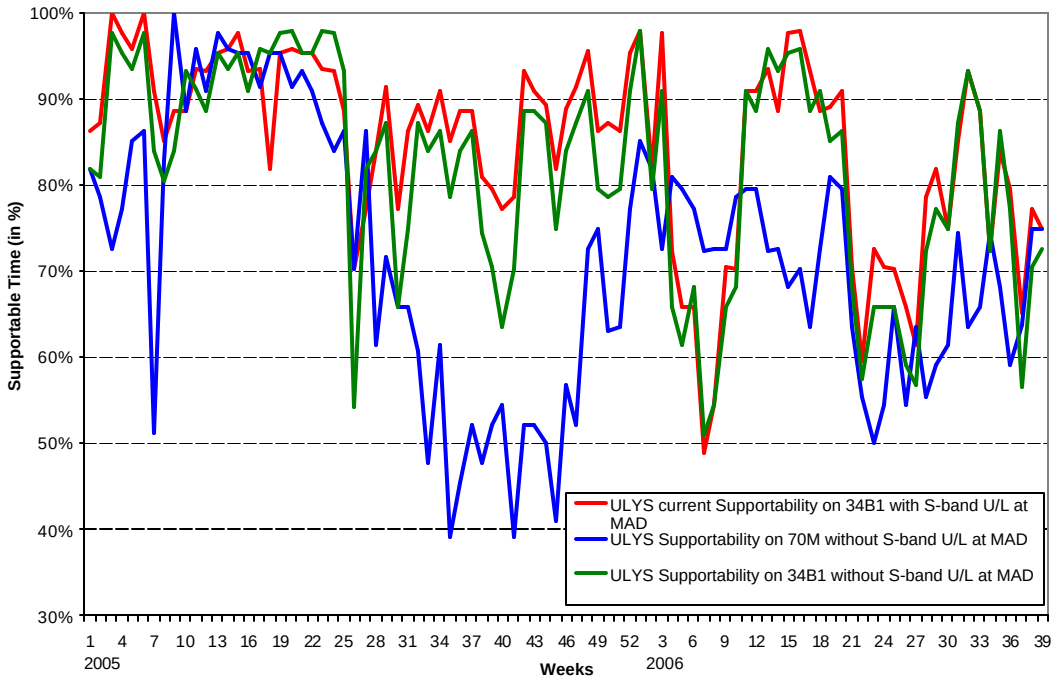
VGR 2 does not have viewperiod at MAD. It requests all support at CAN (DSS-43, 34, 45). Hence not using S-band uplink at Madrid does not impact VGR2 directly.

**Ulysses**

ULYS currently requests seven 5-hour passes weekly at 34BWG1. Figure 3 shows a comparison of the weekly forecasted supportable percentage of time when ULYS has the routine uplink support at GDS, CAN and MAD to when all routine uplink is scheduled at GDS and CAN only on the 34-meter beam wave guide one (BWG1) and 70M subnets.

ULYS has a significant decrease in supportability (ranging from 2 – 15%) as a result of not having S-band uplink at MAD. A few sampled weeks where the supportable percentage of time is extremely low are analyzed further: weeks 26, 30, 40, 45 and 50 in 2005 and weeks 3, 27, 37 and 38 in 2006.

Figure 3 **ULYS Supportability On 70M / 34BWG1 Subnet With / Without S-band U/L at Madrid**




## 2005

In week 26, DSS-24 is down for maintenance. ULYS has contention with requirements supporting Chandra X-ray Observatory (CHDR) and Wind (WIND) routine support, Cassini (CAS) tour, Deep Space Station (DSS) maintenance, Messenger (MSGR) cruise and SOHO keyhole supports. ULYS has 100 % overlap with SOHO, CAS, MSGR,

WIND and with fluctuating CHDR viewperiods. It has 80% overlap with DSS maintenance. (**Please see supporting data attached at the end of study (figures 4 – 7) for viewperiods overlap in 2005 and 2006.)**

In weeks 30 and 40, DSS-43 is down for maintenance. ULYS has contention with requirements supporting CHDR, VGR2 routine support, DSS maintenance, MSGR cruise and Earth swing-by supports. ULYS has 100 % overlap with MSGR and with fluctuating CHDR viewperiods, 80% overlap with DSS maintenance and 45% overlap with VGR2 viewperiods.

In weeks 45 and 50, DSS-43 is still down for maintenance. ULYS has contention with requirements supporting CHDR routine support, DSS maintenance, MSGR cruise and SOHO TSO and keyhole supports. ULYS has 100 % overlap with SOHO, MSGR and with fluctuating CHDR viewperiods. It has 80% overlap with DSS maintenance.

## 2006

In week 5, ULYS has contention with requirements supporting CHDR routine support and New Horizons (NHPC) early ops. ULYS has 70-100% overlap with fluctuating CHDR viewperiods and 80% overlap with NHPC.

In weeks 7 through 10, ULYS has contention with requirements supporting CHDR routine support, Mars Global Surveyor (MGS) mapping, Mars Reconnaissance Orbiter (MRO) approach/DDOR, NHPC early ops and SOHO keyhole support. ULYS has 70-100% overlap with fluctuating CHDR viewperiods, 80% overlap with NHPC, 30% overlap with planet Mars viewperiods and about 20% overlap with SOHO's viewperiod at CAN.

In weeks 22 through 27, ULYS has contention with requirements supporting CHDR routine support, Dawn (DAWN) launch and initial acquisition, DSS maintenance, MGS mapping, MRO aerobraking, MSGR cruise and flip flop, Lunar- A (LUNA) TCM and LOI, NHPC cruise, SOHO keyhole support, Stereo Ahead (STA) prime science and SECCHI campaign, Stereo Behind (STB) prime science and SECCHI campaign. ULYS has 80 – 100% overlap with fluctuating CHDR viewperiods, 45% overlap with DAWN at Canberra, 30-70% overlap with DSS maintenance, 90-100% overlap with planet Mars viewperiods, 100% overlap with MSGR, 100% overlap with LUNA, 70% overlap with NHPC, 50% overlap with SOHO, 50% overlap with STA and 50% overlap with STB.

In weeks 37 and 38, DSS-24 is down for maintenance. In addition ULYS mainly has southern hemisphere view, so all support has to be scheduled at DSS-43 or DSS-34. It has contention with requirements supporting CHDR routine support, DSS maintenance, MRO aerobraking, MSGR cruise, NHPC cruise, SOHO keyhole support, STA prime science and STB prime science.. ULYS has 80 – 100% overlap with fluctuating CHDR viewperiods, 100% overlap with DSS maintenance, 100% overlap with planet Mars viewperiods, 90% overlap with MSGR, 70% overlap with NHPC, 50% overlap with SOHO, 50% overlap with STA and 50% overlap with STB.

During these periods of high contention in 2005 and 2006, having S-band uplink capability at MAD will help reduce the contention at DSS-24 and DSS-34 significantly.

However, inspection of the IMT2000 traffic patterns for the days of the week that SETSI has provided, the time period between 0400 - 0600 UTC during the weekdays and from 0400 - 0700 UTC during weekends is the best time to schedule the S-band uplink pass for Ulysses. Ulysses does not have a Madrid view during this time frame, hence it has to use CAN or GDS view period for the uplink pass to avoid interference with IMT2000 traffic.

In order to reduce contention during the periods of low supportability, the following recommendations are suggested.

**Recommendation 1:**
Without DSS-54, ULYS will need uplink time at DSS-24 (GDS) and/or DSS-34 (CAN). Contention at DSS-34 is very high especially in weeks 29 through 52 of 2005 when DSS-43 is down for antenna controller replacement and hydrostatic bearing maintenance. To accommodate this, ULYS has to reduce uplink time at DSS-34 and use downlink at Madrid.

**Recommendation 2:**
Figure 3 shows that using DSS-14, 43 instead of DSS-24, 34 is useful in certain periods of time especially in week 26 of 2005 when DSS-24 is down and in weeks 4 through 10 of 2006 when 34BWG1 has periods of high activity.

**Recommendation** 3:
Figure 3 also suggests that limiting ULYS to use GDS and /or CAN for S-band uplink, causes a lot of contention on the 34BWG1 and 70M subnets. As a potential remedy, ULYS must limit the use of S-band uplink per day and combine the supports with another X-band downlink only antenna at 34HEF or 34 BWG2 to increase weekly supportable percentage of time for ULYS.

**Conclusion**
In conclusion we believe that not using S-band uplink at MAD does not impact VGR1 in 2005. There is a slight increase in supportable percentage when all uplink support is scheduled at DSS-14 only in 2006. The weekly requested uplink time is low hence moving all uplink support to DSS-14 does not impact VGR1 and the Deep Space Network (DSN) significantly.

ULYS has a significant decrease in supportability as a result of not having S-band uplink at MAD. Contention is mainly due to oversubscription at DSS-34. During the periods of high contention in 2005 and 2006, having S-band uplink capability at MAD will help reduce the contention at DSS-24 and DSS-34 significantly. To avoid interference with the IMT2000 traffic, especially in weeks 29 through 52 of 2005 when DSS-43 is down, ULYS has to reduce uplink time at DSS-34 and use downlink at Madrid.

Using DSS-14, 43 during week 26 of 2005 and weeks 4 through 10 of 2006 helps increase its supportability. To reduce the contention caused by limiting ULYS to use GDS and CAN for S-band uplink, it must limit the use of S-band uplink per day and combine the supports with another X-band downlink only antenna at 34HEF or 34 BWG2.

As always, the results of this study are preliminary in that network loading changes as requirements for planned missions are input and updated. We will continue to work with Voyager1, Ulysses and other users of the DSN to maximize the time available for each individual user.

cc:

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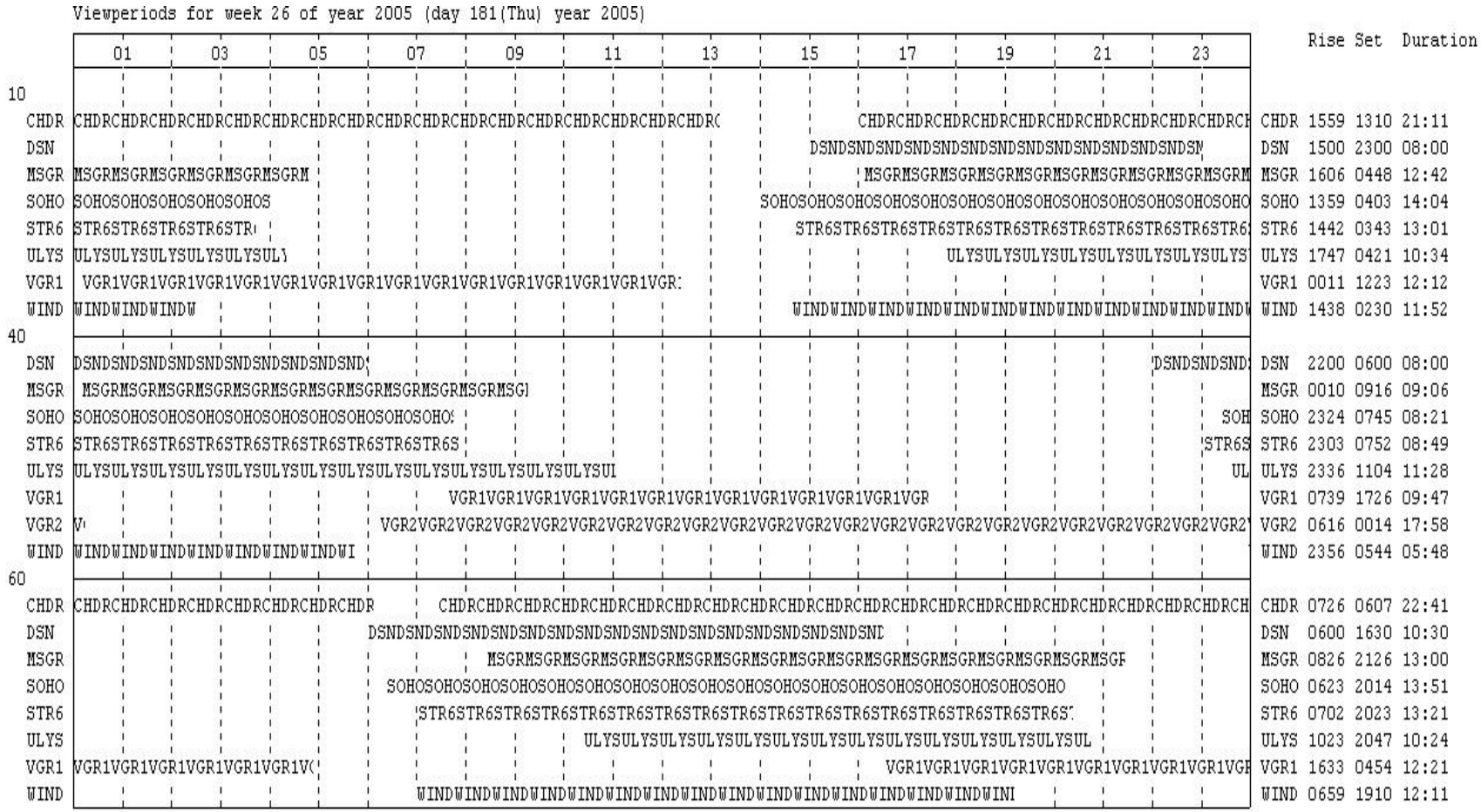
Figure 4


Viewperiods for week 26 of year 2005 (day 181(Thu) year 2005)
01 03 05 07 09 11 13 15 17 19 21 23
Rise Set Duration
10
CHDR CHDRCHDRCHDRC

# Figure 5

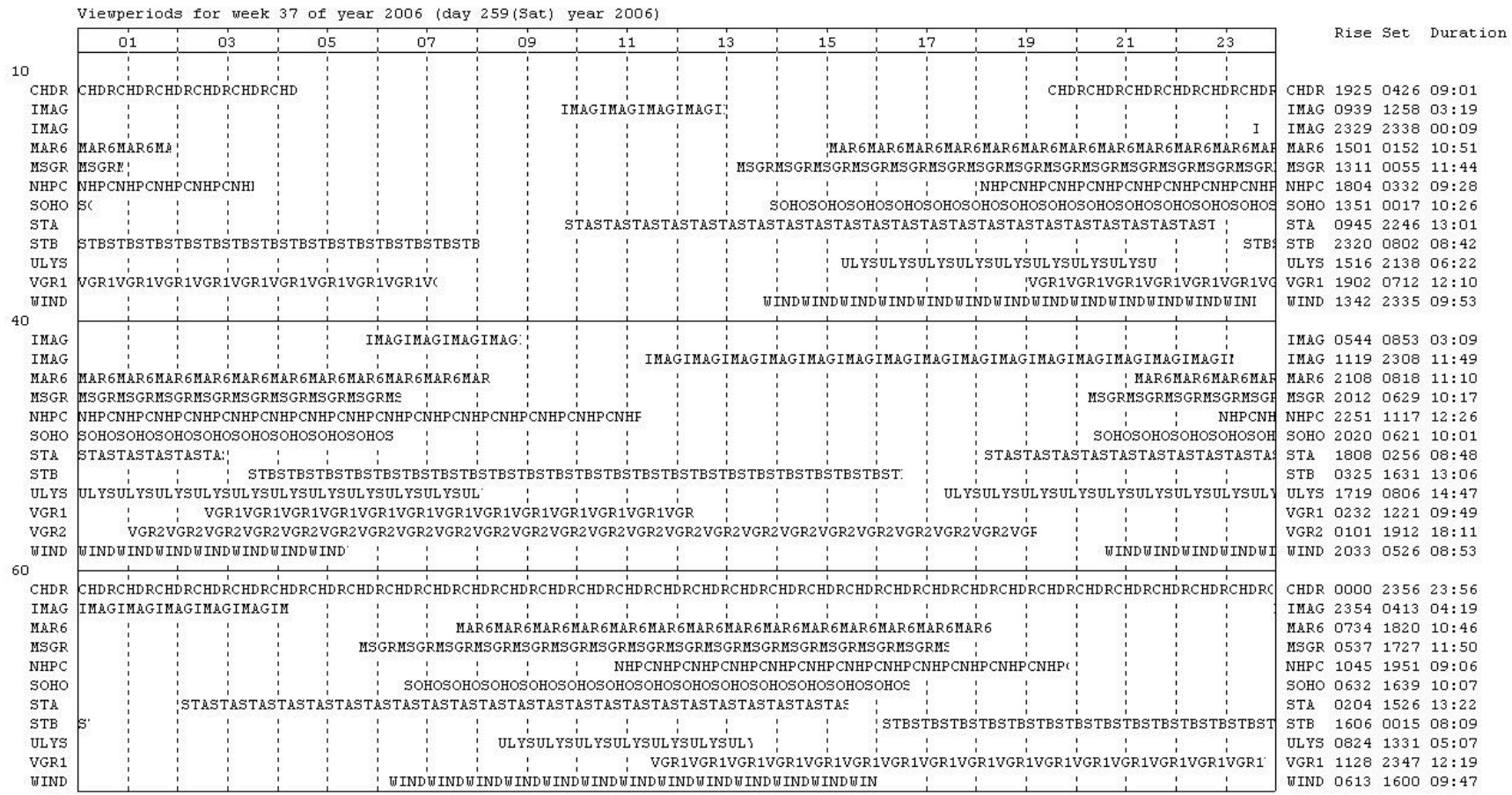
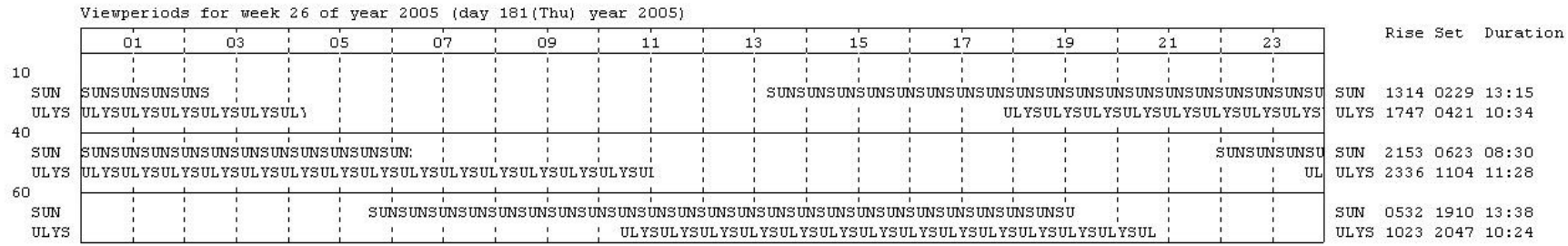

Viewperiods for week 37 of year 2006 (day 259(Sat) year 2006)
01 03 05 07 09 11 13 15 17 19 21 23
Rise Set Duration
CHDR 1925 0426 09:01
IMAG 0939 1258 03:19
IMAG 2329 2338 00:09
MAR6 1501 0152 10:51
MSGR 1311 0055 11:44
NHPC 1804 0332 09:28
SOHO 1351 0017 10:26
STA 0945 2246 13:01
STB 2320 0802 08:42
ULYS 1516 2138 06:22
VGR1 1902 0712 12:10
WIND 1342 2335 09:53
IMAG 0544 0853 03:09
IMAG 1119 2308 11:49
MAR6 2108 0818 11:10
MSGR 2012 0629 10:17
NHPC 2251 1117 12:26
SOHO 2020 0621 10:01
STA 1808 0256 08:48
STB 0325 1631 13:06
ULYS 1719 0806 14:47
VGR1 0232 1221 09:49
VGR2 0101 1912 18:11
WIND 2033 0526 08:53
CHDR 0000 2356 23:56
IMAG 2354 0413 04:19
MAR6 0734 1820 10:46
MSGR 0537 1727 11:50
NHPC 1045 1951 09:06
SOHO 0632 1639 10:07
STA 0204 1526 13:22
STB 1606 0015 08:09
ULYS 0824 1331 05:07
VGR1 1128 2347 12:19
WIND 0613 1600 09:47

Figure 6



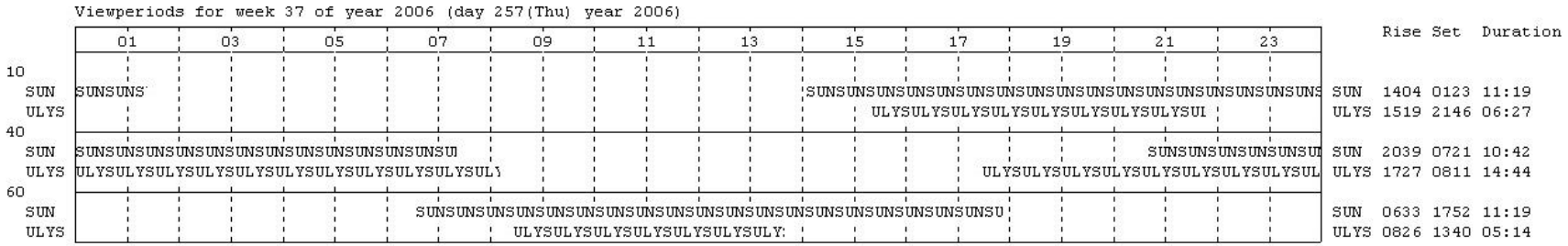


Figure 7